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EXAMINER	
LEE, HSIEN MING	
ART UNIT	**PAPER NUMBER**
2823	

DATE MAILED: 04/23/2003

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary	Application No.	Applicant(s)	
	10/053,288	DALTON ET AL.	
	Examiner	Art Unit	
	Hsien-Ming Lee	2823	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☐ Responsive to communication(s) filed on _____ .

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) 1-20 is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) 1-20 is/are rejected.

7)☒ Claim(s) 16 is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☒ The drawing(s) filed on 17 January 2002 is/are: a)☐ accepted or b)☒ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

11)☐ The proposed drawing correction filed on _____ is: a)☐ approved b)☐ disapproved by the Examiner.

If approved, corrected drawings are required in reply to this Office action.

12)☐ The oath or declaration is objected to by the Examiner.

Priority under 35 U.S.C. §§ 119 and 120

13)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____ .

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

14)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application).

a) ☐ The translation of the foreign language provisional application has been received.

15)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☒ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☒ Information Disclosure Statement(s) (PTO-1449) Paper No(s) 2 .
4) ☐ Interview Summary (PTO-413) Paper No(s). _____ .
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other: .

DETAILED ACTION

Drawings

1. The drawings are objected to as failing to comply with 37 CFR 1.84(p)(5) because they include the following reference sign(s) not mentioned in the description: "100" (Figs.2F-2H and 3F-3H). A proposed drawing correction, corrected drawings, or amendment to the specification to add the reference sign(s) in the description, are required in reply to the Office action to avoid abandonment of the application. The objection to the drawings will not be held in abeyance.

Claim Objections

2. Claim 16 is objected to because of the following informalities: in-consistent terminology, i.e." the lower layer" (line 7) versus "a lower hardmask layer" (line 4). Appropriate correction is required.

Claim Rejections - 35 USC § 102

3. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (e) the invention was described in (1) an application for patent, published under section 122(b), by another filed in the United States before the invention by the applicant for patent or (2) a patent granted on an application for patent by another filed in the United States before the invention by the applicant for patent, except that an international application filed under the treaty defined in section 351(a) shall have the effects for purposes of this subsection of an application filed in the United States only if the international application designated the United States and was published under Article 21(2) of such treaty in the English language.

4. Claims 1, 4-7, 9 and 10 are rejected under 35 U.S.C. 102(e) as being anticipated by Fornof et al. (US 6,537,908).

The applied reference has a common assignee with the instant application. Based upon the earlier effective U.S. filing date of the reference, it constitutes prior art under 35 U.S.C. 102(e). This rejection under 35 U.S.C. 102(e) might be overcome either by a showing under 37

CFR 1.132 that any invention disclosed but not claimed in the reference was derived from the inventor of this application and is thus not the invention "by another," or by an appropriate showing under 37 CFR 1.131.

In re claim 1, Fornof et al. expressly and inherently teach the claimed method for forming a metal pattern in a substrate, the method comprising the steps of:

- depositing a lower hardmask layer 56' (i.e. a polish stop layer) on the substrate 50/52', the lower hardmask layer 56' having a dielectric constant less than about 4.5 (Fig.2B and col. 5, lines 3-6);
- depositing a middle hardmask layer (not shown) on the lower hardmask layer 56' (i.e. when hardmask 54 includes more than two layers, it would have the middle hardmask layer disposed between lower and top hardmask layers, col.3, lines 52-54);
- depositing a top hardmask layer 58' (i.e. a patterning layer) on the middle hardmask layer, the top hardmask layer 58' having a thickness less than about 200 Å (i.e. 100 ~1,000 Å, col. 5, lines 36-39);
- forming a first opening 60 in the top hardmask layer 58' in accordance with a first pattern, thereby exposing a portion of the middle hardmask layer;
- forming a second opening 62 in said portion of the middle hardmask layer and a portion of the lower hardmask layer 56' in accordance with a second pattern and a corresponding opening in the lower hardmask layer 56', thereby exposing a portion of the substrate 52'/50 (Fig.2D);
- forming an opening 64 in the substrate 52'/50 (Fig.2E);
- depositing metal 68 (copper) in the opening 64 in the substrate 52'/50 (Fig.2F); and

- removing the top hardmask layer 58' (Fig.2F).

In re claims 4 and 9, Fornof et al. also inherently teach that the lower hardmask 56' (i.e. the polishing stop layer comprising Si, O, H and optionally C) is of a material selected from the group consisting of SiC:H or SiCOH (col.5, lines 3-14).

In re claims 5 and 10, Fornof et al. also teach that said step of depositing metal 68 further comprises depositing excess metal overlying the top hardmask layer 58', and further comprises the step of removing the excess metal by polishing the metal in a chemical-mechanical polishing (CMP) process (col. 6, lines 55-67), a polishing rate of the top hardmask layer 58' (i.e. organic or inorganic dielectric material) being less than a polishing rate of the metal (i.e. copper).

In re claim 6, Fornof et al. also teach that said step of forming the first opening 60 includes depositing a resist layer (not shown but taught in col. 5,lines 59-64) on the top hardmask layer 58' and subsequently removing the resist layer therefrom (col.6, lines 6-7), and wherein the middle hardmask layer protects the lower hardmask layer 56' from oxidation during removal of the resist layer.

In re claim 7, Fornof et al. expressly and inherently teach the claimed method for forming a metal pattern in a substrate, the substrate 52'/50 having a dielectric constant less than about 4 (i.e. layer 52' having the dielectric constant of 1.1 ~3.5, col. 4, lines 16-18), the method comprising the steps of:

- depositing a lower hardmask layer 56' on the substrate 52'/50, the lower hardmask layer 56' having a dielectric constant less than about 4.5;

- forming a protective layer (i.e. a middle hardmask; when the hardmask 54 includes more than two layers, col.3, lines 52-54) in a region of the lower hardmask layer 56' adjacent to a top surface thereof;
- depositing a top hardmask layer 58' on the lower hardmask layer 56', the top hardmask layer having a thickness less than about 200 Å, as stated above (Fig.2B);
- forming a first opening 60 in the top hardmask layer 58' in accordance with a first pattern, thereby exposing a portion of the lower hardmask layer 56' (Fig.2C);
- forming a second opening 62 in said portion of the lower hardmask layer 56' in accordance with a second pattern, thereby exposing a portion of the substrate 52'/50 (Fig.2D);
- forming an opening 64 in the substrate 52'/50 (Fig.2E);
- depositing metal 68 (copper) in the opening 64 in the substrate 52'/50 (Fig.2F); and
- removing the top hardmask layer 58' (Fig.2F).

Claim Rejections - 35 USC § 102

5. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (g)(1) during the course of an interference conducted under section 135 or section 291, another inventor involved therein establishes, to the extent permitted in section 104, that before such person's invention thereof the invention was made by such other inventor and not abandoned, suppressed, or concealed, or (2) before such person's invention thereof, the invention was made in this country by another inventor who had not abandoned, suppressed, or concealed it. In determining priority of invention under this subsection, there shall be considered not only the respective dates of conception and reduction to practice of the invention, but also the reasonable diligence of one who was first to conceive and last to reduce to practice, from a time prior to conception by the other.

6. Claims 1, 3-7, 9-11 and 15 are rejected under 35 U.S.C. 102(g) as being anticipated by Dalton et al. (U.S. Application Number 09/550,943, submitted by applicants).

In re claim 1, Dalton et al. expressly teach the claimed method for forming a metal pattern in a substrate, the method comprising the steps of:

- depositing a lower hardmask layer 40 on the substrate 10/20/30, the lower hardmask layer 40 (e.g. SiCOH) having a dielectric constant less than about 4.5 (i.e. a dielectric constant of about 2.5~8.0) (Fig.1, page 3, lines 7-9 and page 8, lines 3-10);
- depositing a middle hardmask layer 50 on the lower hardmask layer 40 (Fig.1);
- depositing a top hardmask layer 60 on the middle hardmask layer 50 (Fig.1), the top hardmask layer 60 having a thickness less than about 200 Å (i.e. 100 ~2,000 Å, page 9, lines 3-4);
- forming a first opening 90 in the top hardmask layer 60 in accordance with a first pattern, thereby exposing a portion of the middle hardmask layer 50 (Fig.2);
- forming a second opening 120 in said portion of the middle hardmask layer 50 in accordance with a second pattern and a corresponding opening 120 in the lower hardmask layer 40, thereby exposing a portion of the substrate 10/20/30 (Fig.4);
- forming an opening 125 in the substrate 10/20/30 (Fig.5);
- depositing metal 130 (copper) in the opening 125 in the substrate 10/20/30 (Fig.9); and
- removing the top hardmask layer 60 (Fig.10).

In re claim 3, Dalton et al. also teach that the middle hardmask layer 50 is of a material selected from the group consisting of SiO2, SiN, SiON, and SiOF (page 9, lines 5-9).

In re claims 4 and 9, Dalton et al. also teach that the lower hardmask layer 40 is of a material selected from the group consisting of SiC:H, OSG, amorphous hydrogenated silicon carbide (page 9, lines 5-9).

In re claims 5 and 10, Dalton et al. also teach that said step of depositing metal 130 further comprises depositing excess metal overlying the top hardmask layer 60, and further comprises the step of removing the excess metal by polishing the metal in a chemical-mechanical polishing (CMP) process (page 12, second paragraph), a polishing rate of the top hardmask layer 60 (i.e. SiC) being less than a polishing rate of the metal (i.e. copper).

In re claims 6 and 11, Dalton et al. also teach that said step of forming the first opening 90 includes depositing a resist layer 80 on the top hardmask layer 60 and subsequently removing the resist layer therefrom 80 and wherein the middle hardmask layer 50 protects the lower hardmask layer 40 from oxidation during removal of the resist layer 80 (Figs. 1-2).

In re claim 7, Dalton et al. expressly and inherently teach the claimed method for forming a metal pattern in a substrate, the substrate 10/20/30 having a dielectric constant less than about 4 (i.e. layer 30 is a low k dielectric material, page 7, last paragraph), the method comprising the steps of:

- depositing a lower hardmask layer 40 on the substrate 10/20/30, the lower hardmask layer 40 having a dielectric constant less than about 4.5;
- forming a protective layer 50 (i.e. the middle hardmask) in a region of the lower hardmask layer 40 adjacent to a top surface thereof (Fig.1);
- depositing a top hardmask layer 60 on the lower hardmask layer 40, the top hardmask layer 60 having a thickness less than about 200 Å (Fig.1), as stated above;

- forming a first opening 120 in the top hardmask layer 60 in accordance with a first pattern, thereby exposing a portion of the lower hardmask layer 40 (Fig.4);
- forming a second opening 125 in said portion of the lower hardmask layer 40 in accordance with a second pattern, thereby exposing a portion of the substrate 10/20/30 (Fig.5);
- forming an opening 125 in the substrate 10/20/30 (Fig.5);
- depositing metal 130 (copper) in the opening 125 in the substrate 10/20/30 (Fig.9); and
- removing the top hardmask layer 60 (Fig.10).

In re claim 15, Dalton et al. further teach that the thickness of the protective layer 50 is about 100 Å. (page 9, line 3).

Claim Rejections - 35 USC § 103

7. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

8. Claims 2 and 8 are rejected under 35 U.S.C. 103(a) as being unpatentable over Dalton et al. in view of Fornof et al. (US '908).

Dalton et al. teach the claimed method, as stated above, but fail to teach that the top hardmask layer is of a material selected from the group consisting of refractory metals, refractory metal nitrides, refractory metal alloys, doped amorphous silicon and doped silicon.

However, the selection of the material of the top hardmask layer is obvious because it is a matter of determining optimum process condition by routine experimentation with a limited number of species, as evidenced by Fornof et al. Also, In re Jones, 162 USPQ 224 (CCPA 1955)(the selection of optimum ranges within prior art general conditions is obvious) and In re Boesch, 205 USPQ 215 (CCPA 1980)(discovery of optimum value of result effective variable in a known process is obvious).

In particular, Fornof et al. suggest that in the situation of multiple hardmask layer (i.e. two or more than two layers), the material selection with respect to each hardmask depends on the etching selectivity between adjacent layers (col. 4, line 60 through col.5, line 34). For example, the top hardmask layer can be any material as long as it has a high polishing rate with respect to the underlying layer (i.e. the middle hardmask layer) for the purpose of quick-polishing the top hardmask layer but not over-polishing the middle hardmask layer during CMP polishing (col.5, lines 23-34, Fornof et al.).

Therefore, it would have been obvious to one of the ordinary skill in the art, at the time the invention was made, to select any desired material with the aforementioned requirements as taught by Fornof et al., including the claimed materials, for the top hardmask layer of Dalton et al. since by this manner it would satisfactory remove the top hardmask layer by CMP without compromising the integrity of the underlying middle hardmask layer.

9. Claims 12-14 are rejected under 35 U.S.C. 103(a) as being unpatentable over Fornof et al. (US '908) in view of Catabay et al. (US 6,503,840).

In re claims 12 and 13, Fornof et al. teach the claimed method, including the lower hardmask layer being a *low-dielectric-constant material*, but do not teach exposing the lower

hardmask layer to a *plasma* which *densifies* the lower hardmask layer in said region, so that the protective layer protects the lower hardmask layer from oxidation during removal of the resist layer.

However, Catabay et al. in an analogous art of plasma treatment teach subjecting the low dielectric constant layer to the plasma for densification to *harden* (i.e. increasing density) a surface of the low-dielectric-constant layer. (col. 6, lines 29-35)

Therefore, one of the ordinary skill in the art, at the time the invention was made, would have been motivated to perform the plasma densification as taught by Catabay et al to densify the lower hardmask layer of Fornof et al. since by doing so it would *harden* the surface of the lower hardmask layer, which, in turn, would protect the lower hardmask layer from etching damage during the resist striping.

In re claim 14, Fornof et al. teach all the claimed steps, including removing the resist layer, but fail to teach removing the resist layer in a non-oxidizing resist process.

Catabay et al. teach utilizing the non-oxidizing resist strip process during the formation of the opening to prevent the adjacent dielectric layers from damage (col.6, lines 40-45).

Therefore, it would have been obvious to one of the ordinary skill in the art, at the time the invention was made, to utilize the non-oxidizing resist strip process as taught by Catabay et al. for stripping the resist layer of Fornof et al. since by this manner it would prevent the hardmask layer from damage.

10. Claims 16 and 18-20 are rejected under 35 U.S.C. 103(a) as being unpatentable over Shaffer II et al. (US 2002/0052125) in view of Catabay et al. (US '840).

In re claims 16 and 20, Shaffer II et al. teach the claimed method for forming a metal pattern in a substrate, the substrate 20/10 having a dielectric constant less than about 4 (i.e. layer 20 comprises polyarylene, which has a dielectric constant less than about 3.0, paragraphs [0003] and [0092]), the method comprising the steps of:

- depositing a lower hardmask layer 32 on the substrate 20/10, the lower hardmask layer 32 (i.e. organosilicate) having a dielectric constant less than about 4.5 (Fig.2a);
- depositing a top hardmask layer 34 (i.e. an organosilicate hardmask, paragraph [0066]) on the lower hardmask layer 32, the top hardmask layer 34 having a thickness less than about 200 Å (i.e. the organosilicate hardmask having a thickness greater than 50 Å , paragraph [0066]);
- forming a first opening 35 in the top hardmask layer 34 in accordance with a first pattern, thereby exposing a portion of the lower hardmask layer 32 (Fig.2c);
- forming a second opening 33 in said portion of the lower hardmask layer 32 in accordance with a second pattern, thereby exposing a portion of the substrate 20/10 (Fig.2b);
- forming an opening 21/22 in the substrate 20/10 (Fig.2d);
- depositing metal (copper) in the opening 21/22 in the substrate 20/10 (paragraph [0081]); and removing the top hardmask layer 34 (Fig.2d);

  wherein said step of forming the first opening 35 further comprises depositing a resist layer (not shown, but taught in paragraph [0066]) on the top hardmask layer 34 and subsequently removing the resist layer therefrom.

Shaffer II et al. teach all the claimed steps, including removing the resist layer as stated above, but fail to teach removing the resist layer in a non-oxidizing resist process.

Catabay et al. teach utilizing the non-oxidizing resist strip process during the formation of the opening to prevent the adjacent dielectric layers from damage (col.6, lines 40-45).

Therefore, it would have been obvious to one of the ordinary skill in the art, at the time the invention was made, to utilize the non-oxidizing resist strip process as taught by Catabay et al. for stripping the resist layer of Shaffer II et al. since by this manner it would prevent the hardmask layer from damage.

In re claim 18, Shaffer II et al. in view of Catabay et al. also teach that the lower hardmask layer 32 is of a material selected from the group consisting of SiCOH (i.e. the organosilicate).

In re claim 19, Shaffer II et. al.in view of Catabay et al. further teach that said step of depositing metal (i.e. copper) further comprises depositing excess metal overlying the top hardmask layer, and further comprising the step of removing the excess metal by polishing the metal in a chemical-mechanical polishing (CMP) process, a polishing rate of the top hardmask layer (i.e. organosilicate) being less than a polishing rate of the metal (i.e. copper).

11. Claim 17 is rejected under 35 U.S.C. 103(a) as being unpatentable over Shaffer II et. al. in view of Catabay et al. as applied to claims 16 and 18-20 above, and further in view of Fornof et al. (US '908).

Shaffer II et. al. in view of Catabay et al. teach the claimed method, as stated above, but fail to teach that the top hardmask layer is of a material selected from the group consisting of

refractory metals, refractory metal nitrides, refractory metal alloys, doped amorphous silicon and doped silicon.

However, the selection of the material of the top hardmask layer is obvious because it is a matter of determining optimum process condition by routine experimentation with a limited number of species, as evidenced by Fornof et al. Also, In re Jones, 162 USPQ 224 (CCPA 1955)(the selection of optimum ranges within prior art general conditions is obvious) and In re Boesch, 205 USPQ 215 (CCPA 1980)(discovery of optimum value of result effective variable in a known process is obvious).

In particular, Fornof et al. suggest that in the situation of multiple hardmask layer (i.e. two or more than two layers), the material selection with respect to each hardmask depends on the relative etching selectivity between adjacent layers (col. 4, line 60 through col.5, line 34). For example, the top hardmask layer can be any material as long as it has a high polishing rate with respect to the underlying layer (i.e. the middle hardmask layer) for the purpose of quick-polishing the top hardmask layer but not over-polishing the middle hardmask layer during CMP polishing (col.5, lines 23-34, Fornof et al.).

Therefore, it would have been obvious to one of the ordinary skill in the art, at the time the invention was made, to select any desired material with the aforementioned requirements as taught by Fornof et al. for the top hardmask layer of Shaffer II in view of Catabay et al. since by this manner it would satisfactory remove the top hardmask layer by CMP without compromising the integrity of the middle hardmask layer.

12. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Hsien-Ming Lee whose telephone number is 703-305-7341. The examiner can normally be reached on M-F (9:00 ~ 5:00).

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Olik Chaudhuri can be reached on 703-306-2794. The fax phone numbers for the organization where this application or proceeding is assigned are 703-308-7722 for regular communications and 703-308-7722 for After Final communications.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is 703-308-0956.

Hsien-Ming Lee
Examiner
Art Unit 2823

April 19, 2003